Using Haptics and Sound in a Virtual Gallery

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Introduction

Galleries are traditionally places for visual exploration of objects; concert halls provide auditory exploration. The tools of virtual reality allow for a new kind of gallery: one that encompasses features of a traditional visual museum, means for auditory discovery, and in addition, haptic exploration. The user is invited to browse through this virtual gallery, interacting with the objects, feeling their textures, listening to their audio properties, moving around and inside them. All of this takes place in an interactive, 3D environment where the user navigates and explores with her eyes, ears, and hands.

The Center for Arts and Technology at Connecticut College has provided an atmosphere for interactive collaboration. In the past, many of our projects have involved the interaction between a 3D, visually rich world, and sound. The possibilities for haptic exploration in such a setting were very intriguing, not just for the sake of expanding our digital sensory capabilities to include touch, but also because of the opportunity to explore the interactions and reinforcement among the senses.

Description

The virtual gallery is set inside a hemisphere, with multi-modal sculptures placed near the edge. From the center, where the user enters, the objects are not all clearly visible, although light and vague forms give clues to their presence. At the center of the world the user experiences a dark and foggy atmosphere, with rumbling sounds. As she moves towards the edges of the world there is more light as well as visual and auditory clarity. Nearing an object causes it to come into focus, both visually and through sound. The rumbling noise that she experiences in the center of the world lessens and begins to blend with the individual auditory properties associated with the object itself. Navigation is by means of a joystick, which allows her to move forward or backward, up or down, and yaw from side to side. The user also has stereo eyeglasses, which increase the feeling of immersion in the three-dimensional world. The user's right hand controls a phantom. The model for navigation is that of a person walking through a world, holding a hand out in front. In this virtual world there is no gravity, and both the objects and the user can float in space. Other laws of physics are partially observed, depending on the object: some can be bumped into with the phantom, some are impenetrable, others can be entered.

The virtual gallery is programmed in Visual C++ on a PC and uses Sense8's World Toolkit libraries as well as the Ghost 3 libraries. Models were created in a dxf format and then translated to VRML2, for both the haptic and visual worlds. Because of the addition of the World Toolkit libraries it was necessary to create dual haptic and graphic worlds.

Haptic Interactions

Each of the five objects possesses visual, audio, and tactile properties. As the user nears the object, the sound(s) associated with that object become louder. The audio is spatialized so that

as the user moves around the world, the audio changes. Each object also has haptic characteristics. All of these characteristics interact with each other.

One of the objects is multi-faceted and has many angles on its surfaces. The sound associated with that object is voices which speak and overlap. The surface of the object has some give to it so the user can not only feel the object, but push on it. It is also possible to push through and enter the object, either exploring solely with the phantom, or moving hand and head into the object. If the user enters this object with her head (ears), the audio files exhibit reverberation and the voices seem to echo and bounce off the interior walls. On the inside of the object the user is also able to explore or push back through to the outside. Another of the objects has two moving arms mounted on a central cylinder. Contact with the arms causes them to start swinging and also triggers their individualized sounds. The arms, because they can be in motion, have no haptic properties, although the central cylinder does. Another object consists of interlocking rings. When the user enters the negative space of the holes in the rings she experiences a haptic buzzing, which is accompanied by a sound. The rings themselves have a rather hard surface and as the user presses on them with the phantom she causes a change to a higher pitch in their sound. Pressure on the rings and the rise in pitch are correlated on a sliding scale. One of the other objects is in motion as the user approaches, with the haptics turned off. When the user touches it (as determined in the graphics world) the haptics are activated and the user is able to explore its surface. Another object has hollow bumps or hemispheres on its surface and as the user goes up inside these hemispheres the viscosity of the phantom increases while at the same time the pitch of the associated sound is lowered. This causes the sensation of moving inside a thick substance where time has slowed. Throughout all of our design we have looked for ways in which the multiple senses can interact and reinforce one another.

Phantom Challenges

The necessity for including virtual reality libraries made it impossible to use the OpenGL Ghost environment. Thus it was necessary to create dual haptic and graphic environments. This situation was made more complex because Ghost and Sense8 have different coordinate conventions.

A more major difficulty occurred in setting up navigation for the phantom. Because the user is free to move around the world, it was necessary to translate the center of the phantom (in the virtual world) and also adjust its direction. Navigation is by means of a joystick held in the left hand; the joystick represents the head (and body) of the user. We restricted navigation to forward/backward, yawing from side to side, and up/down elevator motion (using a button). This navigation seemed to be simple enough to master quite easily, and flexible enough to move the user where she wishes to go with relative ease. The right hand operates the phantom; the visual point of contact (in the virtual world) of the phantom is represented by a small, slightly glowing sphere. The paradigm is that of a human: the right hand can move, but it is attached to the body and so as the body moves through the gallery, the hand moves with it, maintaining its relative position. The difficulty that this presented was that movement with the joystick could easily cause the phantom to come in contact with an object, causing a conflict. Initially this gave rise to a constant vibration in the phantom. The (somewhat OK) programming fix was to first check to see if the phantom is in contact with any of the objects. If it was, we don’t update its

position. If not and if either the magnitude of the translation or the magnitude of directional shift is greater than some fixed lower bounds, update the phantom. Some slight adjustments had to be made when considering the particular object into which the user can enter: in this case we had to set touchableByPhantom to FALSE, move the phantom, and then set it back to TRUE. For all of the objects we still encoucntered the problem of coming up in the middle of an object and thus causing excessive force, but could not find a good way around this. Setting the objects so they can't be felt by the phantom begs the question. We thought of moving the phantom away from the object slightly so that we wouldn't have immediate contact, but then we ran into the problem of what constitutes the inside and the outside of objects, and this question is already vexing enough for our graphics. The problem of navigation is certainly the largest one we encountered and we have not solved it to our satisfaction.

Other problems were more standard. We get low frame rate, even with a dual processor and a graphics card. This is probably because, in addition to the graphics and haptics, we are doing real-time sound processing: spatializing, mixing sounds together, changing pitches, adding reverberations, etc. Another problem is the proliferation of devices: manipulating a world that includes eyeglasses or HMD, sound, joystick and phantom creates a cumbersome environment, but a manageable one.

Future Research

The project we are currently working on is really a test bed for using haptics, vision, and audio in a 3D world. We have been very pleased with the results so far. We are particularly excited about the opportunities that haptics presents in these types of arts and technology collaborations. There are some additional tests we would like to do in the present project to make the interface run more smoothly and to get the frame rate down. Future work of this nature includes a project to explore an abandoned abbey (Tintern) by re-creating the original structure, allowing the user to explore and feel. We will use textures from photographs and we envision the user being able to touch the walls, causing them to crumble into the ruins of today. We have also been talking with colleagues about the possibility of using haptics to "feel" the envelopes of musical sound, manipulating audio properties in an interactive manner. The Center for Arts and Technology is an ideal venue for taking haptics in some of these new directions.

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